137. We reduce the value of the intercept to $.46 from $.80 in the equation proposed in the *Inputs Further Notice* for calculating the labor and material costs for buried copper cable (excluding structure, LEC engineering, and splicing costs). We now estimate the buried 24-gauge copper cable and structure regression equation after removing the multi-cable variable and adding the water indicator variable. The value of the intercept in this regression equation of $1.16 is less than the intercept in the proposed regression equation of $1.51. As we did in the *Inputs Further Notice*, we derive the buried copper cable equation from the regression equation for 24-gauge buried copper cable and structure costs. The value of the intercept in the buried copper cable and structure regression equation represents the fixed cost for both buried copper cable and buried copper cable structure in density zone 1. We assume, as we did in the *Inputs Further Notice*, that $.70 is the fixed cost for buried copper cable structure in density zone 1. Accordingly, the fixed labor and material cost for buried copper cable is $1.16 minus $.70, or $.46.

138. We also reduce the value of the intercept to $.47 from $.60 in the equation proposed in the *Inputs Further Notice* for calculating the labor and material costs for buried fiber cable (excluding structure, LEC engineering, and splicing costs). We now estimate the buried fiber cable and structure regression equation after removing the multi-cable variable. The value of the intercept in this regression equation, $1.17, is greater than the value of the intercept in the proposed regression equation, $1.14. As we did in the *Inputs Further Notice*, we derive the buried fiber cable equation from the regression equation for buried fiber cable and structure costs. The value of the intercept in the buried fiber cable and structure regression equation represents the fixed cost for both buried fiber cable and buried fiber cable structure in density zone 1. We assume that $.70 is the fixed cost for buried fiber cable structure in density zone 1. Accordingly, the fixed labor and material cost for buried fiber cable in density zone 1 is $1.17 minus $.70 or $.47

139. Huber Adjustment. In the *Inputs Further Notice*, we tentatively concluded that one substantive change should be made to Gabel and Kennedy's analysis.[304] As we explained, we tentatively concluded that the regression equations in the NRRI Study should be modified using the Huber regression technique[305] to mitigate the influence of outliers in the RUS data.[306] Statistical outliers are values that are much higher or lower than other data in the data

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[304] *Inputs Further Notice* at para. 75.

[305] We used Stata Statistical Software: Release 5 (Stata) to perform the calculations needed to estimate the regression equations adopted in this Order for cable and structure costs. Stata has a robust regression methodology that uses formulas developed by P.J. Huber, R.D. Cook, A.E. Beaton and J.W. Tukey. We used this methodology to estimate the regression equations for cable and structure costs. We refer to this robust regression methodology as the Huber methodology. *See Stata Reference Manual, Release 5*, Volume 3, P-Z, Stata Press, College Station, TX, 168-173.

[306] *Inputs Further Notice* at para. 76.

set. The Huber algorithm uses a standard statistical criterion to determine the most extreme outliers and exclude those outliers. Thereafter, the Huber algorithm iteratively performs a regression, then for each observation calculates an observation weight based on the absolute value of the observation residual. Finally, the algorithm performs a weighted least squares regression using the calculated weights. This process is repeated until the values of the weights effectively stop changing.[307]

140. We affirm our tentative conclusion to modify the regression equations in the NRRI Study using the Huber methodology to develop input values for cable and structure costs. The cable and structure cost inputs used in the model should reflect values that are typical for cable and structure for a number of different density and terrain conditions. If they do not reflect values that are typical, the model may substantially overestimate or underestimate the cost of building a local telephone network. As discussed below, application of the Huber methodology minimizes this risk, thereby producing estimates that are consistent with the goal of developing cable and structure cost inputs that reflect values that are typical for cable and structure for different density and terrain conditions.

141. The commenters attest to the fact that there are significant variances in the RUS structure and cable cost data.[308] We find that the presence of these outliers warrants the use of the Huber methodology. By relying on the Huber methodology to identify and to exclude or give less than full weight to these data outliers in the regressions, we decrease the likelihood that the cost estimates produced reflect measurement error or data anomalies that may represent unusual circumstances that do not reflect the typical case. We note that we are not readily able to ascertain the specific circumstances that may explain why some data points are outliers relative to more clustered data points because of the multivariate nature of the database. Such occurrences are expected when dealing with such a database. Not only are there many observations, but these observations reflect the circumstances surrounding the construction work of many different contractors done for a large number of companies on different projects over a number of years. We also note that the task of identifying structure cost outliers without using a statistical approach such as Huber is especially difficult because these costs are a function of different geological conditions and population densities. Given that it is not feasible, as a practical matter, to determine why particular data points are outliers and our objective is to develop typical cable and structure costs, we conclude that use of the

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[307] As noted in the *Inputs Further Notice*, we used the robust regression parameter estimates for cable, conduit, and buried structure. The use of robust estimation did not improve the statistical properties of the estimators for pole costs, so we tentatively concluded that the ordinary least squares technique is appropriate for pole costs. The value of the F-statistic was not statistically significant at the five percent level. *Inputs Further Notice* at para. 76 n. 161.

[308] *See e.g.*, GTE *Inputs Further Notice* comments at 23-26; Bell Atlantic *Inputs Further Notice* comments at 17, Attachment C at 29-34; US West *Inputs Further Notice* comments, Attachment A at 11-13; BellSouth *Inputs Further Notice* comments, Attachment A at A-17.

Huber methodology is appropriate.[309]

142.   We find the comments opposing application of the Huber methodology unpersuasive. In the first instance, we reject the assertions of the commenters, either express or implied, that the application of robust regression analysis is not the preferred method of dealing with outliers in a regression.[310] There is no preferred method. The use of robust regression techniques is a matter of judgement for the estimator. As we explained above, the goal of our analysis is to estimate values that are typical for cable and structure costs for different density and terrain conditions. We determined that we should mitigate the effects of outliers occurring in the data to ensure that the estimates we produce reflect typical costs. Noting that such outliers have an undue influence on ordinary least squares regression estimates because the residual associated with each outlier is squared in calculating the regression, we determined, in our expert opinion, to employ the Huber methodology to diminish the destabilizing effects of these outliers. Thus, while it can be argued that we could have produced a different estimate, the commenters have not established that application of the Huber methodology produces an unreasonable estimate.

143.   Bell Atlantic and GTE assert that the probability distribution of the error term must be symmetric about its mean and have fatter tails than in the normal distribution in order to use the Huber methodology.[311] We disagree. The Huber methodology in effect fits a line or a plane to a set of data. The algebraic expression of this line or plane explains or predicts the effects on a dependent variable, e.g., 24-gauge aerial copper cable cost, of changes in independent variables, e.g., aerial copper cable size. It does this by assigning zero or less than full weight to observations that have extremely high or extremely low values. The assignment of weights to observations depends on the values of the observations. It does not depend on the probability of observing these values. The error term to which Bell Atlantic and GTE refer is the difference between the predicted or estimated values of the dependent variable and the observed values of the dependent variable. Given that the error term is the difference between the predicted and observed values of the dependent variable, and that the assignment of weights by the Huber methodology does not depend on the probability of observing particular values of this variable, this assignment of weights does not depend on the probability of observing particular values of the error term. It, therefore, does not depend on

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[309] For example, for one to determine why the reported structure cost for a single project is an outlier, one would have to interview the LEC engineers and contractors to verify the reported cost, identifying with precision whether unusual circumstances surrounded the project thereby leading to atypical costs.

[310] *See e.g.*, GTE *Inputs Further Notice* comments at 23-26; Bell Atlantic *Inputs Further Notice* comments at 17, Attachment C at 29-34; US West *Inputs Further Notice* comments, Attachment A at 11-13; BellSouth *Inputs Further Notice* comments, Attachment A at A-17.

[311] *See* Bell Atlantic *Inputs Further Notice* comments at 17, Attachment C at 30, 31; *See* GTE *Inputs Further Notice* comments at 25.

whether the probability distribution of the error term is symmetric about its mean and has fatter tails than in the normal distribution.

144. Bell Atlantic also argues that the Huber methodology should not be used unless there is evidence that outliers in the RUS data are erroneous.[312] We disagree. We believe that use of the Huber methodology with RUS data ensures that cost estimates reflect typical costs regardless of whether there is evidence that outliers in the RUS data are erroneous. The RUS data, as Bell Atlantic and other parties point out, have a number of high values and low values.[313] These outliers may reflect unusual circumstances that are unlikely to occur in the future. The Huber methodology dampens the effects of anomalistically high or low values that may reflect unusual circumstances. Notwithstanding the dispersion in the RUS data, we believe that there are relatively few errors in these data. As we explained, the RUS data are derived from contracts. Gabel and Kennedy determined that the values reflected in the RUS data are within one percent of the values set forth on the contracts.[314] There are likely to be few errors in the contracts themselves because these are binding agreements that involve substantial sums of money between RUS companies and contractors. These parties have an obvious interest in ensuring that these values are correctly reflected in these contracts. While we believe that errors in these contracts are likely to be infrequent, outlier observations in the RUS data may reflect large errors. The Huber methodology dampens the effects of outlier observations that may reflect large errors.

145. We find that the estimates produced by applying the Huber methodology are reasonable. As we explain more fully in Appendix B, the estimates resulting from application of the Huber methodology reflect most of the information represented in nearly all of the cable and structure cost observations in the RUS data. Approximately 80 percent of the cable and structure observations are assigned a weight of at least 80 percent in each structure and regression equation that we adopt. This large majority comprises closely clustered observations that clearly represent typical costs. Conversely, approximately 20 percent of the cable and structure observations are assigned a weight of less than .8 in each of these regression equations. This small minority comprises observations that have extremely high and extremely low values that do not represent typical costs. We also note that because the Huber methodology treats symmetrically observations that have high or low values, it excludes or assigns less than full weight to data outliers without regard to whether these are high or low cost observations.

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[312] *See* Bell Atlantic *Inputs Further Notice* comments at 17.

[313] Bell Atlantic *Inputs Further Notice* comments, Attachment C at 23, 24. *See also* GTE *Inputs Further Notice* comments at 17, 18; AT&T *Inputs Further Notice* comments at 14.

[314] NRRI Study at 34.

146. Buying Power Adjustment. In the *Inputs Further Notice*, we tentatively concluded that we should make three adjustments to the regression equations in the NRRI Study, as modified by the Huber methodology described above, to estimate the cost of 24-gauge aerial copper cable, 24-gauge underground copper cable, and 24-gauge buried copper cable.[315] We further tentatively concluded that these adjustments should be made in the estimation of the cost of aerial fiber cable, buried fiber cable, and underground fiber cable.[316] The first of these adjustments was to adjust the equation to reflect the superior buying power that non-rural LECs may have in comparison to the LECs represented in the RUS data. We noted that Gabel and Kennedy determined that Bell Atlantic's material costs for aerial copper cable are approximately 15.2 percent less than these costs for the RUS companies based on data entered into the record in a proceeding before the Maine Public Utilities Commission (the "Maine Commission").[317] Similarly, Gabel and Kennedy determined that Bell Atlantic's material costs for aerial fiber cable are approximately 33.8 percent less than these costs for the RUS companies.[318] We also noted that Gabel and Kennedy determined that Bell Atlantic's material costs for underground copper cable are approximately 16.3 percent less than these costs for the RUS companies and 27.8 percent less for underground fiber cable. We tentatively concluded that these figures represent reasonable estimates of the difference in the material costs that non-rural LECs pay in comparison to those that the RUS companies pay for cable.[319] Accordingly, to reflect this degree of buying power in the copper cable cost estimates that we derived for non-rural LECs, we proposed to reduce the regression coefficient for the number of copper pairs by 15.2 percent for aerial copper cable, and 16.3 percent for 24-gauge underground copper cable.

147. We also proposed to reduce the regression coefficient for the number of fiber strands by 33.8 percent for aerial fiber cable and 27.8 percent for underground fiber cable.[320] As we explained, this coefficient measures the incremental or additional cost associated with one additional copper pair or fiber strand, as applicable, and therefore, largely reflects the material cost of the cable. Because the NRRI Study did not include a recommendation for such an adjustment for buried copper cable or buried fiber, we tentatively concluded we should reduce the coefficient by 15.2 percent for buried copper cable and 27.8 percent for

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[315] *Inputs Further Notice* at paras. 77-81; 82; 83-84.

[316] *Inputs Further Notice* at paras. 90-95.

[317] *Inputs Further Notice* at para. 79 n. 163 *citing* NRRI Study at 47.

[318] *Inputs Further Notice* at para. 91 n. 174 *citing* NRRI Study at 47.

[319] *Inputs Further Notice* at paras. 79, 82.

[320] *Inputs Further Notice* at paras. 91, 93.

buried fiber cable.[321] We explained that the level of these adjustments reflect the lower of the reductions used for aerial and underground copper cable and aerial and underground fiber cable, respectively.

148.   We adopt the tentative conclusion in the *Inputs Further Notice* and select buying power adjustments of 15.2 percent, 16.3 percent and 15.2 percent for 24-gauge aerial copper cable, 24-gauge underground copper cable, and 24-gauge buried copper cable, respectively. Correspondingly, we adopt buying power adjustments of 33.8 percent, 27.8 percent, and 27.8 percent for aerial fiber cable, underground fiber cable, and buried fiber cable, respectively. We find that, based on the record before us, the buying power adjustment is appropriate and the levels of the adjustments we proposed for the categories of copper and fiber cable we identified are reasonable.

149.   As we explained in the *Inputs Further Notice*, the buying power adjustment is intended to reflect the difference in the materials prices that non-rural LECs pay in comparison to those that the RUS companies pay.[322] Because non-rural LECs pay less for cable, a downward adjustment to the estimates developed from data reflecting the costs of rural-LECs is necessary to derive estimates representative of cable costs for non-rural LECs. The commenters generally concede that such differences exist.[323] There is, however, disagreement among the commenters that an adjustment is necessary in this instance to reflect this difference.

150.   Those commenters advocating the use of company-specific data oppose the buying power adjustment as unnecessary. GTE and Sprint contend that the use of a more representative data set, i.e., company-specific data, would account for any differences in buying power.[324] As we explained above, however, the RUS data are the most reliable data on the record before us for estimating cable and structure costs. Because there is a difference in the material costs that non-rural LECs pay in comparison to those that the RUS companies pay, a downward adjustment to the RUS cable estimates is necessary to obtain representative cable cost estimates for non-rural LECs.

151.   We note that AT&T and MCI support the proposed adjustment for aerial and

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[321] *Inputs Further Notice* at paras. 84, 95.

[322] *Inputs Further Notice* at para. 79.

[323] *See e.g.,* SBC *Inputs Further Notice* comments at 8; Sprint *Inputs Further Notice* comments at 22; Sprint *Inputs Further Notice* reply comments at 15; AT&T and MCI *Inputs Further Notice* comments at 21.

[324] GTE *Inputs Further Notice* comments at 26-27; Sprint *Inputs Further Notice* reply comments at 14.

underground copper and fiber cable.[325] AT&T and MCI oppose, however, the use of the lower of the reductions adopted for aerial and underground cable categories, for the buried cable category. Although AT&T and MCI agree that an adjustment is appropriate for buried cable, they contend that the buying power adjustment should be set at the higher figures of 16.3 percent for buried copper cable and 33.8 percent for buried fiber cable, or at the very least, at the average of the higher and lower values for aerial and underground cable. We disagree. We find that AT&T and MCI offer no support to demonstrate why the higher values should be used. As explained below, the levels of the adjustments we proposed and adopt are the most conservative based on the available record evidence.

152.   Apart from opposing the buying power adjustment on the ground that as a general matter the adjustment is unnecessary, those opposing the adjustment take issue with the adjustment on methodological grounds. GTE contends that the adjustment cannot properly convert RUS data into costs for non-rural carriers because the RUS data do not reflect the cost structure of rural carriers.[326] As we explained above, the assertion that the RUS data does not reflect the cost structure of rural carriers is without merit. GTE also contends that the application of the adjustment factors to the coefficients in the regression equations is contrary to the fundamentals of sound economic analysis.[327] The solution GTE recommends is that additional observations for non-rural companies be added to the data set. This solution echoes GTE's assertion that company-specific data should be used. Reliable observations for non-rural LECs are not available, however, as explained above.

153.   GTE also identifies what it considers flaws in the development of the buying power adjustment.[328] GTE argues that because the adjustment to the RUS data was developed using only one larger company's data (Bell Atlantic's) reflecting costs for a single year, the adjustment is not proper.[329] We disagree for several reasons. First, we note that although we specifically requested comment on this adjustment and its derivation in the *Inputs Further Notice*,[330] GTE and other parties challenging the use of Bell Atlantic's data have not provided any alternative data for measuring the level of market power, despite their general agreement

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[325]   AT&T and MCI *Inputs Further Notice* comments at 21.

[326]   GTE *Inputs Further Notice* comments at 26.

[327]   GTE *Inputs Further Notice* comments at 27.

[328]   GTE *Inputs Further Notice* comments at 28.

[329]   GTE *Inputs Further Notice* comments at 28.

[330]   *Inputs Further Notice* at para. 79.

that such market power exists.[331] These parties failed to submit comparable verifiable data to show that the buying power adjustment we proposed was inaccurate. Under these circumstances, we cannot give credence to the unsupported claims that the Bell Atlantic data is not representative.

154. Equally important, we have reason to conclude that the adjustment we adopt is a conservative one. The buying power adjustment we proposed and adopt is based upon a submission by Bell Atlantic to the Maine Commission in a proceeding to establish permanent unbundled network element (UNE) rates.[332] In that context, it was in Bell Atlantic's interests to submit the highest possible cost data in order to ensure that the UNE rates would give it ample compensation. But in the context of the adjustment we consider here for buying power, a relatively higher cost translates into a reduced adjustment because the greater the LEC costs, the less the differential between LEC and rural carrier costs. Therefore, given the source of this data, we conclude that it is likely to produce a conservative buying power adjustment, not an excessive one. Nevertheless, in the proceeding on the future of the model, we intend to seek further comment on the development of an appropriate buying power adjustment to reflect the forward-looking costs of the competitive efficient firm. In sum, we find that GTE's criticisms are not persuasive, and that the adjustment is a reasonable one, supported by the record.

155. GTE also asserts a litany of other concerns that, according to GTE, render the buying power adjustment invalid.[333] We find these concerns unpersuasive. GTE claims that the adjustment is suspect because some RUS observations used in the determination of material costs are not used in the regression.[334] We disagree. As discussed above, we apply the Huber methodology to RUS cable costs that reflect both labor and material costs.[335] The observations in the RUS database to which the Huber methodology assigns zero or less than full weight are those with the highest and the lowest values. As described more fully below, a statistical analysis demonstrates that this assignment of weights to these observations has little impact on the level of material costs reflected in the cable cost estimates derived by using this methodology. Therefore, material cost averages based on all of the RUS data are not likely to vary significantly from material cost averages based on a subset of these data.

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[331] Such agreement is consistent with representations by parties in merger contexts that a merger will produce costs savings.

[332] NRRI Study at 47. *See Inputs Further Notice* at para. 79.

[333] GTE *Inputs Further Notice* comments at 28-29.

[334] GTE *Inputs Further Notice* comments at 29.

[335] *See supra* paras. 139-145.

156.   Specifically, with one exception, the value of the regression coefficient for the variable representing the size of the cable in the cable cost regression equations derived by using the Huber methodology lies inside the 95 percent confidence interval surrounding the value of this coefficient in these regression equations in the NRRI Study obtained by using ordinary least squares.[336] The coefficient for the variable that represents cable size represents the additional cost for an additional pair of cable and therefore represents cable material costs. The values of the coefficient for the cable size variable obtained by using Huber and ordinary least squares are based on a sample of RUS companies' cable costs drawn from a larger population of such costs. The values of the coefficient obtained from this sample by using the Huber methodology and ordinary least squares are estimates of the true values of this coefficient theoretically obtained from the population of cable costs by using these techniques. Generally speaking, a 95 percent confidence interval associated with a coefficient estimate contains, with a probability of 95 percent, the true value of the coefficient.[337] The fact that the value of the cable size coefficient obtained by using the Huber methodology lies within an interval that contains with 95 percent certainty the true value of the ordinary least squares cable size coefficient supports the conclusion that the Huber methodology does not by its weighting methodology have a statistically significant impact on the level of the material costs reflected in the cable cost estimates derived by using this methodology.[338]

157.   GTE also claims that some RUS observations appear to be from rescinded contracts or contracts excluded from the NRRI Study per-foot cable cost calculation.[339] However, GTE offers no evidence that this is the case. Finally, GTE claims that some RUS observations are for technologies that may not be appropriate for a forward-looking cost

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[336] We set forth in Appendix B a table that shows the value of this regression coefficient derived by using the Huber methodology and the 95 percent confidence interval surrounding the value of this coefficient obtained by using ordinary least squares. We also discuss in more detail the statistical evidence on the impact of the Huber methodology on the level of the material costs reflected in the cable cost estimates.

[337] As a general matter, 95 percent of the confidence intervals associated with different estimates of a given coefficient derived from a large number of samples of a given population can be expected to contain the true value of the coefficient.

[338] The one exception is that the value of the cable size coefficient obtained by using the Huber methodology for buried copper cable lies outside the 95 percent confidence interval associated with the cable size coefficient for buried copper cable obtained in the NRRI Study using ordinary least squares. This suggests that the assignment of weights by the Huber methodology does have a statistically significant impact on the level of the buried material costs reflected in the buried cable cost estimates. We find that this does not lead to an unreasonable estimate for buried cable costs. As we explained, application of the Huber methodology results in a better estimate of the expected value or tendency of the material costs for the RUS companies. Moreover, as noted above, the level of the buying power adjustment we adopt for buried copper cable is the most conservative estimate on the record before us.

[339] GTE *Inputs Further Notice* comments at 29.

model.[340] On the contrary, loading coils were excluded from the RUS data base. Thus, we find that the RUS data do not reflect any non-forward-looking technologies.

158.   GTE and Sprint each attempt to impugn the validity of the buying power adjustment, claiming that there may be an incongruity between the data submitted to the Maine Commission by Bell Atlantic and the RUS data.[341] We find this claim unpersuasive. Both GTE and Sprint assert that it is unknown whether the underlying data include such items as sales tax or shipping costs and, if so, whether the level of these items is comparable between Maine and the states included in the RUS data. Significantly, neither claim that such an incongruity exists in fact, nor do they provide viable alternatives for the calculation of the adjustment. We note that the RUS data reflect the same categories of costs as those reflected in the Bell Atlantic data. More importantly, this data reflects the best available evidence on the record on which to base the buying power adjustment.

159.   BellSouth claims that the buying power adjustment is flawed because it does not take into account the exclusion of RUS data resulting from the Huber adjustment.[342] Bell Atlantic makes a similar claim.[343] Both parties argue that because the Huber methodology excludes high cost data from the regression analysis, it is inappropriate to apply a discount which essentially has the same effect. In sum, these commenters claim that we are adjusting for high material costs twice. We disagree. This contention ignores the fact that the application of the Huber methodology and the buying power adjustment are fundamentally different adjustments. The Huber adjustment gives reduced weight to observations that are out of line with other data provided by the RUS companies. The Huber adjustment provides coefficient estimates that can be used to estimate the cost incurred by a typical RUS company. The adjustment is designed to dampen the effect of outlying observations that otherwise would exhibit a strong influence on the analysis. The large buying power adjustment, on the other hand, adjusts for the greater buying power of the non-rural companies. None of the RUS companies have the buying power of, for example, Bell Atlantic or GTE, and therefore have to pay more for material. The buying power adjustment could only duplicate the Huber adjustment if some of the RUS companies have the buying power of a company as large as Bell Atlantic. Because none of the firms in the RUS data base are close to the size of Bell Atlantic, the commenters are incorrect when they assert that, since the Huber methodology excludes high cost data from the regression analysis, it is inappropriate to apply the buying power adjustment.

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[340] GTE *Inputs Further Notice* comments at 29.

[341] GTE *Inputs Further Notice* comments at 28-29; Sprint *Inputs Further Notice* comments at 22-23.

[342] BellSouth *Inputs Further Notice* comments, Attachment A at A-5, A-18.

[343] Bell Atlantic *Inputs Further Notice* comments, Attachment C at 22-23, 27.

160.   We also reject BellSouth's argument that, to determine the size of the buying power adjustment, we should use a weighted average of the cable price differentials between Bell Atlantic and the RUS companies that is based on the miles of cable installed, not the number of observations, for each cable size.[344] In the NRRI Study, this weighted average price differential is determined by: (1) calculating the price differential between Bell Atlantic's average cable price and the RUS companies' average cable price for each cable size; (2) weighting the price differential for each cable size by the number of observations used to calculate the RUS companies' average cable price; and (3) summing these weighted price differentials.[345] The average measures the central tendency of the data. In general, the average more reliably measures this central tendency the larger the number of observations from which this average is calculated. In the NRRI Study, the average cable prices calculated for the RUS companies that reflect a relatively large number of observations are more reliable than those that reflect relatively few observations. Accordingly, weighting the price differentials for each cable size by the number of observations reflected in the average cable price calculated for the RUS companies provides a weighted average that reliably measures the central tendency of the price. In contrast, use of the miles of cable installed as weights to determine the average cable price differentials could result in a less reliable measure of central tendency because price differentials based on a small number of observations but reflecting a high percentage of cable miles purchased would have a greater impact on the weighted average than price differentials based on a large number of observations of cable purchase prices. Moreover, use of the number of miles of cable installed as the weights would result in a weighted average price differential that reflects RUS companies' relative use of different size cables. The RUS companies' relative use of different size cables is irrelevant for use in a model used to calculate non-rural LECs' cost of constructing a network.

161.   We also reject Bell Atlantic's contention that the buying power adjustment is flawed because it should have been applied to the material costs rather than the regression coefficient of copper cable pairs or the number of fiber strands.[346] Bell Atlantic has provided no evidence that demonstrates that applying the discount to the coefficient is incorrect. It is an elementary proposition of statistics that the result of applying the discount to the regression coefficient is equal to applying the discount to the material costs.[347] Significantly, Bell Atlantic has not demonstrated that applying the discount to the regression coefficient does not produce the same result as applying the discount to the material costs.

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[344] BellSouth *Inputs Further Notice* comments, Attachment A at A-18.

[345] NRRI Study at 47 n. 47.

[346] Bell Atlantic *Inputs Further Notice* comments, Attachment C at C-27.

[347] $E(aX) = aE(X)$ where "a" is the discount factor and X is the price of cable. *See, e.g.*, Gerald Keller and Brian Warrick, *Statistics for Management Economics* at 206 (Fourth Edition, Duxbury, 1997).

162.   Finally, we disagree with Sprint that, because buying power equates to company size, it is inappropriate to apply this adjustment uniformly to all carriers.[348] We are estimating the costs that an efficient provider would incur to provide the supported services.[349] We are not attempting to identify any particular company's cost of providing the supported services. We find, therefore, that applying the buying power adjustment as we propose is appropriate for the purpose of calculating universal service support.

163.   In sum, we find unpersuasive the criticisms of the buying power adjustment we proposed. We conclude that, based on the record before us, a downward adjustment to the estimates developed from data reflecting the cable costs of rural LECs is necessary to derive estimates representative of cable costs for non-rural LECs and that the levels we have proposed for this adjustment are reasonable.

164.   LEC Engineering. The second adjustment we proposed to the regression equations used to estimate cable costs was to account for LEC engineering costs, which were not included in the RUS data.[350] As we noted, the BCM2 default values include a loading of five percent for engineering.[351] In contrast, the HAI sponsors claimed that engineering constitutes approximately 15 percent of the cost of installing outside plant cables.[352] This percentage includes both contractor engineering and LEC engineering. The cost of contractor engineering already is reflected in the RUS cable cost data. In the *Inputs Further Notice*, we tentatively concluded that we should add a loading of 10 percent to the material and labor costs of cable (net of LEC engineering and splicing costs) to approximate the cost of LEC engineering.[353]

165.   We affirm our tentative conclusion to add a loading of 10 percent to the material and labor for the cost of cable (net of LEC engineering and splicing costs) to approximate the cost of LEC engineering. We find that, based on the record before us, the

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[348] Sprint *Inputs Further Notice* comments at 22. *See also* Cincinnati Bell *Inputs Further Notice* comments at 3-5.

[349] *See supra* at paragraph 29.

[350] *See Inputs Further Notice* at paras. 80, 91. It should be noted that the LEC Engineering Adjustment as well as the Splicing Adjustment discussed *infra* in paragraphs 168-176 would be required in the estimation of costs for rural LECs from the RUS data base because such costs were not reflected in the RUS data. These adjustments are part of the process in developing estimates from the data.

[351] *Inputs Further Notice* at para. 80.

[352] *Inputs Further Notice* at para. 80.

[353] *Inputs Further Notice* at paras. 80, 82, 84, 91, 93, 95.

proposed LEC engineering adjustment, as modified below, is appropriate. We also find that the level of the adjustment we proposed is reasonable. We note that there is a general consensus among the commenters that the proposed adjustment is necessary.[354] We reject, however, the contentions of those commenters that advocate that the level of the LEC adjustment be based on company-specific data. As we explained above, we find such data to be unreliable. For similar reasons, we reject the LEC engineering adjustment proposed by AT&T and MCI. As we explained, AT&T and MCI's proposal is based on expert opinions which we find to be unsupported and, therefore, unreliable.[355] Accordingly, the level of the adjustment that we proposed, which, as we explained in the *Inputs Further Notice* represents the mid-point between the HAI default loading and the BCPM default loading, is the most reasonable value on the record before us.

166.   Sprint contends that we should calculate the loadings for LEC engineering on a flat dollar basis rather than on a fixed percentage of the labor and material costs of cable.[356] We find persuasive Sprint's contention that LEC engineering costs do not vary with the size of the cable and therefore do not vary with the cost of the cable. Accordingly, we find it reasonable to apply the loading for LEC engineering in the manner that Sprint recommends.

167.   We also find that the commenters are correct that the loading for LEC engineering should not reflect any adjustment for buying power because the buying power differential between non-rural and rural LECs only relates to materials.[357] We adjust our calculation accordingly. Similarly, we also find it appropriate to include in the loading for LEC engineering an allowance for LEC engineering associated with splicing.[358] We find that this is appropriate because the loading for LEC engineering is based on BCPM and HAI default values for this loading that are expressed as a percentage of cable costs inclusive of

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[354] *See e.g.*, GTE *Inputs Further Notice* comments at 31-32; AT&T and MCI *Inputs Further Notice* comments at 16-18; BellSouth *Inputs Further Notice* comments, Attachment B at B-8 - B-9; BellSouth *Inputs Further Notice* reply comments at 6-7; Sprint *Inputs Further Notice* comments at 24-25; Bell Atlantic *Inputs Further Notice* reply comments, Attachment A at 1.

[355] AT&T and MCI *Inputs Further Notice* comments at 16.

[356] Sprint *Inputs Further Notice* comments at 24.

[357] *See e.g.*, GTE *Inputs Further Notice* comments at 26-28; BellSouth *Inputs Further Notice* comments, Attachment B at B-9.

[358] AT&T and MCI develop equations for engineering costs that reflect engineering costs associated with splicing. *See* AT&T and MCI *Inputs Further Notice* comments, Exhibit A at A-7.

engineering.[359]

168. Splicing Adjustment. The third adjustment to the regression equations that we proposed in the *Inputs Further Notice* was to account for splicing costs, which also were not included in the RUS data.[360] As we explained, Gabel and Kennedy determined that the ratio of splicing costs to copper cable costs (excluding splicing and LEC engineering costs) is 9.4 percent for RUS companies in the NRRI Study.[361] Similarly, Gabel and Kennedy determined that the ratio of splicing costs to fiber cable costs (excluding splicing and LEC engineering costs) is 4.7 percent.[362] Thus, we tentatively concluded that we should adopt a loading of 9.4 percent for splicing costs for 24-gauge aerial copper cable, 24-gauge underground copper cable, and 24-gauge buried copper cable.[363] Correspondingly, we tentatively concluded that we should adopt a loading of 4.7 percent for splicing costs for aerial fiber cable, underground fiber cable, and buried fiber cable.[360]

169. We affirm these tentative conclusions. We find that, based on the record before us, the splicing cost adjustment is appropriate and the levels of the adjustments proposed are reasonable. In reaching this conclusion, we reject the claims of those

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[359] We develop the flat cost-per-foot loading for LEC engineering for each type of cable by first estimating the RUS companies' total cable cost inclusive of splicing and exclusive of LEC engineering costs based on: (1) the regression equations we adopt in this Order; (2) the number of feet of cable that was placed pursuant to the contracts from which the data used to develop these regression equation are derived; and (3) the loadings that we adopt in this Order for splicing costs, 9.4 percent for copper cable and 4.7 percent for fiber cable. We then compute for each type of cable the total LEC engineering cost based on the total cable cost inclusive of LEC splicing costs and the loading that we adopt in this Order for LEC engineering, 10 percent. Finally, for each type of cable, we compute the flat cost per foot loading for LEC engineering by dividing the total LEC engineering costs by the total number of feet of cable placed pursuant to the RUS contracts.

Based on this methodology, we derive values for LEC engineering costs of $.19, $1.50, $.16, $.19, $.65, and $.14 per foot for 24-gauge aerial copper cable costs, 24-gauge underground copper cable costs, 24-gauge buried copper cable costs, aerial fiber cable costs, underground fiber cable costs, and buried fiber cable costs, respectively. We add these LEC engineering costs to the cable cost estimates derived by using the Huber methodology.

[360] *See Inputs Further Notice* at paras. 81, 91.

[361] *Inputs Further Notice* at para. 81 n. 164 *citing* NRRI Study at 29.

[362] *Inputs Further Notice* at para. 91 n. 176 *citing* NRRI Study at 29.

[363] *Inputs Further Notice* at paras. 81, 82, 84.

[360] *Inputs Further Notice* at paras. 91, 93, 95.

commenters that advocate the use of company-specific data to develop the splicing loadings.[361] For the reasons enumerated above, we find such data unreliable.

170. We disagree with GTE's claim that, because the splicing factor is based on the RUS data, it is flawed.[362] This contention echoes GTE's assertion that we should use company-specific data. As we explained above, however, we conclude that such data are not reliable. We also disagree with GTE's contention that an analysis of the source contract data shows that some splicing costs are invalid.[363] GTE is mistaken. The RUS cost data from which the regression equations in the NRRI Study and in this Order are derived exclude splicing costs. Cable cost estimates obtained by using this methodology and these data are net of LEC engineering and splicing costs. We add to these cable cost estimates a loading factor for splicing that Gabel and Kennedy developed separately using the RUS data in the NRRI Study without using the regression analysis. In the NRRI Study, Gabel and Kennedy determined the ratio of splicing to cable costs by comparing the cost for splicing and the cost for cable (exclusive of splicing and LEC engineering costs) reflected in the contracts included in the RUS data base. Some of the splicing costs reflected in this database are relatively high and some are relatively low. None of these high or low values is likely to influence significantly this ratio because it reflects a large number of observations. Accordingly, we find it reasonable to apply the splicing ratios developed in the NRRI Study to the cable cost estimates developed separately in this Order by using the Huber methodology with the RUS data.

171. We also disagree with AT&T and MCI's contention that, rather than adopting the proposed splicing loadings or the incumbent LEC's loading factors, we should adopt "reasonable values for the costs of cable placing, splicing, and engineering based on the expert opinions submitted in this proceeding."[364] As discussed above, we find that these expert opinions are unsupported, and therefore unreliable.

172. For the same reason, we also find unpersuasive AT&T and MCI's claim that the loading of 9.4 percent for splicing copper cable is excessive.[365] AT&T and MCI estimates that splicing costs vary between 3.4 and 6.9 percent of cable investment in contrast to the

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[361] *See e.g.*, GTE *Inputs Further Notice* comments at 32 and 50; Sprint *Inputs Further Notice* comments at 27; BellSouth *Inputs Further Notice* comments, Attachment A at A-9 - A-11, and Attachment B at B-8; BellSouth *Inputs Further Notice* reply comments at 6-7.

[362] GTE *Inputs Further Notice* comments at 49.

[363] GTE *Inputs Further Notice* comments at 49.

[364] AT&T and MCI *Inputs Further Notice* comments at 16.

[365] AT&T and MCI *Inputs Further Notice* comments at 16-18.

proposed rate of 9.4 percent. We find that these estimates, which rely on assumptions concerning the per-hour cost of labor, the number of hours required to set up and close the splice, the number of splices per hour, and the distance between splices, are unreliable. AT&T and MCI have provided no evidence other than the unsupported opinions of their experts to substantiate these data. In contrast, Bell Atlantic supports the use of the 9.4 percent loading indicating, that this level is consistent with its own data.[366]

173. While Sprint agrees that a splicing loading is required in the NRRI regression, Sprint recommends that a flat dollar "per pair per foot" cost additive should be employed rather than the adjustment we proposed.[367] We disagree. We find that Sprint's flat dollar "per pair per foot" cost additive ignores the differences in set-up costs among different cable sizes. In contrast, the percent loading for splicing costs we adopt herein implicitly recognizes such differences because these loadings are applied to cable costs estimates (exclusive of splicing and LEC engineering costs) derived from regression equations that have an intercept term that provides a measure of the fixed cost of cable. Accordingly, we conclude that the percent loading approach is more reasonable.

174. Sprint also asserts that underground splicing costs are higher due to the need to work in manholes.[368] We agree. The dollar amounts associated with the fixed percentage loadings adopted in this Order for underground copper and fiber cable are generally larger than for aerial and buried copper cable and fiber cable. The dollar amounts that we adopt for splicing are generally larger for underground cable because the costs that we develop from RUS data for underground cable net of splicing and engineering costs are generally larger than the costs that we develop for aerial and buried cable net of splicing and engineering costs. As a result, when the fixed percentage is applied to these cable costs, the dollar amount for splicing is generally larger for underground cable than for aerial and buried cable.[369]

175. We disagree with those commenters who argue that the splicing costs do not

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[366] Bell Atlantic *Inputs Further Notice* reply comments, Attachment A at 1.

[367] Sprint *Inputs Further Notice* comments at 25. We note that Sprint advocates the use of company-specific data in the first instance.

[368] Sprint *Inputs Further Notice* comments at 25.

[369] There is one instance where the underground cable costs that we develop from RUS data (net of splicing and engineering costs) are not the largest for a given cable size. For the largest fiber cable size, 288 pairs, the costs that we develop for buried cable, $12.07 per foot, are greater than those for underground cable, $11.96 per foot. However, the model is unlikely to frequently place the largest fiber cable size in the network it builds in high-cost areas because most high-cost areas are in the lowest density zones where use of such a cable provides too much capacity relative to demand.

vary with the cost of cable (net of splicing costs).[370] We find that cable costs increase as the size of the cable increases. Splicing costs increase as the size of the cable increases because larger cables require more splicing than small cables. Therefore, splicing costs increase as the cost of the cable increases.

176. Finally, we disagree with SBC's claim that the 14 percent splicing factor for fiber cable is more appropriate than the 4.7 percent we proposed.[371] We find that the 14 percent factor SBC proposes is unsupported. SBC asserts that this factor is based on an average cost ratio from an analysis using various lengths of underground fiber placement, including placing labor and comparing it to associated splicing costs from current cost dockets. However, SBC has not provided this analysis on the record.

177. 26-Gauge Copper Cable. In the *Inputs Further Notice*, we explained that, because the NRRI Study did not provide estimates for 26-gauge copper cable, we must either use another data source or find a method to derive these estimates from those for 24-gauge copper cable.[372] To that end, we tentatively concluded that we should derive cost estimates for 26-gauge cable by adjusting our estimates for 24-gauge cable.[373] We proposed to estimate these ratios using data on 26-gauge and 24-gauge cable costs submitted by Aliant and Sprint and the BCPM default values for these costs.[374] We noted, that while we would prefer to develop these ratios based on data from more than these three sources, we tentatively concluded that these were the best data available on the record for this purpose.

178. We affirm our tentative conclusion to derive cost estimates for 26-gauge cable by adjusting our estimates for 24-gauge cable. As we explained in the *Inputs Further Notice*, we agree with the BCPM sponsors that the cost of copper cable should not be estimated based solely on the relative weight of the cable.[375] Instead, we proposed to use the ordinary least squares regression technique to estimate the ratio of the cost of 26-gauge to 24-gauge cable for each plant type (i.e., aerial, underground, buried). We conclude that, based on the record before us, this approach, adjusted as described more fully below, is reasonable.

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[370] *See e.g.*, Sprint *Inputs Further Notice* reply comments at 16; GTE *Inputs Further Notice* reply comments 26-27.

[371] SBC *Inputs Further Notice* comments at 9.

[372] *Inputs Further Notice* at para. 85.

[373] *Inputs Further Notice* at para. 86.

[374] We did not use the HAI default values in addition to these data to estimate these ratios because the HAI defaults do not have separate values for 26-gauge and 24-gauge cable costs for each different cable size.

[375] *Inputs Further Notice* at para. 86.

179. Consistent with their position on estimating the costs of 24-gauge cable, many commenters advocate that we use company-specific data to estimate the costs of 26-gauge cable.[376] As we explained above, we have determined that such data are not sufficiently reliable to employ in the model.[377] Accordingly, we reject the use of company-specific data to estimate the costs of 26-gauge cable. We note that AT&T and MCI endorse the derivation of cost estimates for 26-gauge cable from estimates for 24-gauge cable.[378] Notwithstanding their support of the general approach we proposed, AT&T and MCI oppose estimating the ratio of costs of 26-gauge cable to 24-gauge cable using the cable costs submitted by Aliant and Sprint and the BCPM default values. Instead, AT&T and MCI advocate the use of the relative weight of copper to adjust the cost of the 24-gauge copper.[379] AT&T and MCI claim that this approach is the most logical because 26-gauge copper costs are directly proportional to the weight of the metallic copper in the cable. We reject AT&T and MCI's recommended approach. We find that, because AT&T and MCI have provided no evidence that the weight differential is approximately equal to the price differential, there is insufficient evidence on the record demonstrating the reasonableness of this approach.

180. Many of those commenters advocating the use of company-specific data contend that there are flaws in the methodology adopted herein to derive cost estimates for 26-gauge cable by adjusting our estimates for 24-gauge cable. Bell Atlantic and GTE contend that our methodology results in biased estimates due to statistical error.[380] We agree and modify our proposed methodology as explained below.

181. As we explained in Appendix D of the *Inputs Further Notice*, in order to derive the 26-gauge copper cable costs, we first estimated the cost for 24-gauge copper cable for each cable size from the RUS data using the Huber methodology.[381] More specifically, we obtained an estimate of the expected or mean value of the cost for 24-gauge copper cable (for given values of the independent variables in the regression equation). We then obtained values for the ratio of 24-gauge copper cable to 26-gauge copper cable for each cable size using *ex parte* data obtained from Aliant and Sprint and BCPM default values for the costs

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[376] *See e.g.*, BellSouth *Inputs Further Notice* comments at 6-7, Attachment B at B-8 - B-9; GTE *Inputs Further Notice* comments at 48.

[377] *See supra* paragraph 92.

[378] AT&T and MCI *Inputs Further Notice* comments at 19-20.

[379] AT&T and MCI *Inputs Further Notice* comments at 19-20.

[380] Bell Atlantic *Inputs Further Notice* comments, Attachment C at 26-27; GTE *Inputs Further Notice* comments at 29-30.

[381] *Inputs Further Notice*, Appendix D.

and employing ordinary least squares regression analysis. As a result, we obtained an estimate of the expected value of the ratio of 24-gauge copper cable to 26-gauge copper cable (for given values of the independent variables in the regression equation). Finally, we multiplied the reciprocal of this ratio by the cost of 24-gauge copper cable obtained by using the Huber methodology with RUS data to obtain the proposed 26-gauge copper cable cost for each copper cable size. Bell Atlantic and GTE contend, and we agree, that this is a biased estimate of the expected value of the cost for 26-gauge copper cable because the expected value of the ratio of two random variables, e.g., 26-gauge copper cable cost and 24-gauge copper cable, does not equal the ratio of the expected value of the first random variable to the expected value of the second random variable. We note that the magnitude of the bias is larger as the difference grows between the expected value of the ratio of 26-gauge copper cable cost to 24-gauge copper cable cost and the ratio of the expected value of 26-gauge copper cable cost to the expected value of 24-gauge copper cable cost.

182.   Accordingly, we modify the methodology tentatively adopted in the *Inputs Further Notice* to derive estimates of 26-gauge copper cable costs from 24-gauge copper cable costs that are not biased. As explained in more detail in Appendix B, in addition to estimating the expected value of the cost for 24-gauge copper cable for each cable size using the RUS data, we also estimate the expected value of the costs of 24-gauge and 26-gauge copper cable for each cable size using the data submitted by Aliant and Sprint and the BCPM default values, as well as data submitted by BellSouth,[382] hereinafter identified in the aggregate as "the non-rural LEC data." We divide the estimate of the expected value for 24-gauge copper cable cost derived from the non-rural LEC data into the estimate of the expected value for 26-gauge copper cable cost derived from these data for each cable size. The result is a ratio of an estimate of the expected value for 26-gauge copper cable cost to an estimate of the expected value for 24-gauge cable cost for each cable size. Finally, we multiply this ratio by the estimate of the expected value of the cost for 24-gauge copper cable derived from the RUS data to obtain an estimate of the expected value of the cost for 26-gauge copper cable for each cable size. We find that this adjustment eliminates the bias identified by the commenters. We conclude, therefore, that these estimates are reasonable and adopt them as inputs for 26-gauge copper cable costs.

183.   We note that, in adopting these modifications, we find that it is reasonable to rely on the non-rural LEC data for calculating the ratio of the cost for 24-gauge copper cable to that for 26-gauge copper cable, but not for calculating the absolute cost for 24-gauge copper cable and 26-gauge copper cable. As discussed above, we find that the non-rural LEC data are not a reliable measure of absolute costs. Notwithstanding this finding, we conclude that it is reasonable to use the non-rural LEC data to determine the relative value of the cost for 24-gauge copper cable to that for 26-gauge copper cable. We find that it is reasonable to conclude that each LEC used the same methodology to develop both 24-gauge and 26-gauge

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[382]   BellSouth *Inputs Further Notice* reply comments, Attachment A at A-22 - A-23.

copper cable costs. Accordingly, any bias in the costs for 24-gauge and 26-gauge copper cable that results from using a given methodology is likely to be in the same direction and of a similar magnitude. As a consequence, the estimate of the expected value of the cost for 26-gauge copper cable for each cable size and the estimate of the expected value of the cost for 24-gauge copper cable obtained from non-rural LEC data are likely to be biased by approximately the same factor. The ratios of the estimates of these expected values are not likely to be affected significantly because the bias in one estimate approximately cancels the bias in the other estimate when the ratio is calculated.

184.   GTE also contends that the proposed methodology systematically reduces the amount of labor associated with placing cable.[383] We conclude that the adjustments made in response to GTE and Bell Atlantic's criticisms discussed above render this criticism irrelevant. We find that no systematic bias will result because the ratio of the 24-gauge cost of copper cable to the cost of 26-gauge copper cable represents the installed cost of 26-gauge copper cable including all labor and materials divided by the installed cost of 24-gauge copper cable including all labor and materials. Moreover, this ratio is applied to the installed cost of 24-gauge copper cable which includes all labor and material costs.

185.   BellSouth claims that neither the data used to develop the ordinary least squares regression equation we employ in the *Inputs Further Notice* to estimate the cost of 26-gauge copper cable or the computations used to derive that equation have been provided.[384] BellSouth contends that, as a result, it is not possible to confirm or contradict the discount value. We disagree. Contrary to BellSouth's assertion, the data are available. As we explained, the regression equation uses *ex parte* data submitted by Aliant and Sprint. These data are available subject to the Commission's rules regarding the treatment of confidential material. We also note that the BellSouth data we employ in the adjusted methodology we adopt herein are publicly available. Moreover, the BCPM data are publicly available.

5.   Cable Fill Factors

a.   Background

186.   As we explained in the *Inputs Further Notice*, in determining appropriate cable sizes, network engineers include a certain amount of spare capacity to accommodate administrative functions, such as testing and repair, and some expected amount of growth.[385] The percentage of the total usable capacity of cable that is expected to be used to meet

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[383]   GTE *Inputs Further Notice* comments at 48-50.

[384]   BellSouth *Inputs Further Notice* comments, Attachment A at A-19.

[385]   *Inputs Further Notice* at para. 96.

current demand is referred to as the cable fill factor.[386] If cable fill factors are set too high, the cable will have insufficient capacity to accommodate small increases in demand or service outages. In contrast, if cable fill factors are set too low, the network could have considerable excess capacity. While carriers may choose to build excess capacity for a variety of reasons, it is necessary to determine the appropriate cable fill factors for use in the federal mechanism. We also explained that, if the fill factors are too low, the resulting excess capacity would increase the model's cost estimates to levels higher than an efficient firm's costs, potentially resulting in excessive universal service support payments. Accordingly, as discussed more fully below, we tentatively selected the HAI defaults for distribution fill factors, the average of the HAI and BCPM default values for copper feeder fill factors, and fiber fill factors of 100 percent.[387]

187. <u>Variance Among Density Zones</u>. As a preliminary matter, we noted that both the HAI and BCPM sponsors provided default fill factors for copper cable that vary by density zone, and that both agreed that fill factors should be lower in the lowest density zones.[388] We explained that the HAI sponsors claimed that an outside plant engineer is more interested in providing a sufficient number of spares than in the ratio of working pairs to spares, so the appropriate fill factor will vary with cable size.[389] Because smaller cables are used in lower density zones, HAI recommended that lower fill factors be used in the lowest density zones to ensure there will be enough spares available. Similarly, the BCPM sponsors claimed that less dense areas require lower fill ratios because the predominant plant type is buried and it is costly to add additional capacity after installation.[390] We tentatively agreed with the HAI and BCPM sponsors that fill factors for copper cable should be lower in the lowest density zones, and reflected this relationship in the fill factors that we proposed in the

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[386] We note that the actual fill factor may be lower than the fill factor used to design the network (sometimes referred to as administrative fill), because cable and fiber are available only in certain sizes. For example, assume a neighborhood with 100 households has a current demand of 120 telephones. Dividing the 120-pair demand by an 80 percent administrative fill factor establishes a need for 150 pairs. Cable is not sold, however, in 150-pair units. The company would purchase the smallest cable that is sufficient to provide 150 pairs, which is a 200 pair cable. The fill factor that occurs and is measurable, known as the effective fill, would be the number of pairs needed to meet demand, 120 pairs, divided by the number of pairs installed, 200 pairs, or 60 percent.

[387] *Inputs Further Notice* at paras. 100, 101, 102.

[388] *Inputs Further Notice* at para. 97. As explained below, default values in BCPM 3.1 for distribution cable do not vary by density zone.

[389] *Inputs Further Notice* at para. 97 n. 187 *citing* HAI Dec. 11, 1997 submission, Inputs Portfolio at 39, 63.

[390] *Inputs Further Notice* at para. 97 n. 188 *citing* BCPM 3.1 May 26, 1998 (Preliminary Edition) Loop Inputs Documentation at 51.

Inputs Further Notice.[391]

188. <u>Distribution Fill Factors</u>. We also noted in the *Inputs Further Notice* that the fill factors proposed by the HAI sponsors for distribution cable were somewhat lower than for copper feeder cable.[392] In contrast, the BCPM default fill factors for distribution cable are set at 100 percent for all density zones.[393] We explained that this difference is related to the differences between certain assumptions that were made in the HAI and BCPM models. The HAI proponents claimed that the level of spare capacity provided by their default values is sufficient to meet current demand plus some amount of growth.[394] This is consistent with the HAI model's approach of designing plant to meet current demand, which on average is 1.2 lines per household as defined by HAI. BCPM, on the other hand, designs outside plant with the assumption that every residential location has two lines, which is more than current demand. This reflects the practice of incumbent LECs to build enough distribution plant to meet not only current demand, but also anticipated future demand because it is costly to add distribution plant at a later point in time.[395]

189. We also noted that, in a meeting with Commission staff, Ameritech raised the issue of whether industry practice is the appropriate guideline for determining fill factors to use in estimating the forward-looking economic cost of providing the services supported by the federal mechanism.[396] Ameritech claimed that forward-looking fill factors should reflect enough capacity to provide service for new customers for a few years until new facilities are built, and should account for the excess capacity required for maintenance and testing,

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[391] *Inputs Further Notice* at para. 97.

[392] *Inputs Further Notice* at para. 98 n. 189 *citing* HAI Dec. 11, 1997 submission, Inputs Portfolio at 39, 63. HAI 5.0 default values range from 50 percent in the lowest density zone to 75 percent in the highest density zone for distribution cable sizing fill factors, and range from 65 percent in the lowest density zone to 75 percent in the highest density zone for copper feeder cable sizing fill factors.

[393] *Inputs Further Notice* at para. 98 n. 190 *citing* BCPM Dec. 11, 1997 submission. We noted that earlier versions of BCPM, however, had lower fill factors for distribution than for feeder. *See, e.g., 1997 Further Notice* at para. 118. Default values in BCPM 3.1 range from 75 to 85 percent for feeder cable.

[394] *Inputs Further Notice* at para. 98 n. 191 *citing* HAI Dec. 11, 1997 submission, Inputs Portfolio at 39, 63.

[395] For example, in an *ex parte* meeting on March 24, 1999, Ameritech representatives said that Ameritech designs distribution plant to meet "ultimate" demand and designs feeder plant that is "growable." *See* Letter from Celia Nogales, Ameritech, to Magalie Roman Salas, FCC, dated March 25, 1999 (Ameritech March 25 *ex parte*).

[396] *Inputs Further Notice* at para. 99.

defective copper pairs, and churn.[397]

190.   We tentatively concluded that the fill factors selected for use in the federal mechanism generally should reflect current demand,[398] and not reflect the industry practice of building distribution plant to meet "ultimate" demand. We also tentatively selected the HAI defaults for distribution fill factors and tentatively concluded that they reflect the appropriate fill needed to meet current demand.[399]

191.   Feeder Fill Factors. In the *Inputs Further Notice* we explained that, in contrast to distribution plant, feeder plant typically is designed to meet only current and short term capacity needs.[400] We noted that the BCPM copper feeder default fill factors are slightly higher than HAI's, but both the HAI and BCPM default values appear to reflect current industry practice of sizing feeder cable to meet current, rather than long term, demand.[401] We tentatively selected copper feeder fill factors that are the average of the HAI and BCPM default values because both the HAI and BCPM default values assume that copper feeder fill reflects current demand.[402]

192.   Fiber Fill Factors. We also explained in the *Inputs Further Notice* that, because of differences in technology, fiber fill factors typically are higher than copper feeder fill factors.[403] Standard fiber optic multiplexers operate on four fiber strands: primary optical transmit, primary optical receive, redundant optical transmit, and redundant optical receive. In determining appropriate fiber cable sizes, network engineers take into account this 100 percent redundancy in determining whether excess capacity is needed that would warrant application of a fill factor.[404] Both the HAI and BCPM models use the standard practice of providing 100

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[397] *Inputs Further Notice* at para. 99 n. 194. Ameritech filed data, subject to the protective order in this proceeding, showing how these considerations are used to calculate the actual and forward-looking fill factors in Ameritech's territory. *See* Ameritech March 25 *ex parte.*

[398] We define "current demand" to include a reasonable amount of excess capacity to accommodate short term growth. *Inputs Further Notice* at para. 100 n. 195.

[399] *Inputs Further Notice* at para. 100.

[400] *Inputs Further Notice* at para. 101 *citing* Ameritech March 25 *ex parte.*

[401] *Inputs Further Notice* at para. 101.

[402] *Inputs Further Notice* at para. 101.

[403] *Inputs Further Notice* at para. 102.

[404] That is, fiber plant with a 100 percent fill factor has an actual utilization of 50 percent; whereas copper plant with a 50 percent fill factor has an actual utilization of 50 percent.

percent redundancy for fiber and set the default fiber fill factors at 100 percent. Accordingly, we tentatively concluded that the input value for fiber fill in the federal mechanism should be 100 percent.[405]

b.   Discussion

193.   We affirm our tentative conclusion that fill factors for copper cable should be lower in the lowest density zones. Significantly, those commenters addressing this issue agree that lower density zones should utilize lower copper cable fill factor inputs.[406] We also reject, at the outset, certain assertions made by GTE and others, challenging the overall approach we proposed and adopt herein for determining the appropriate cable fill factors to use in the federal mechanism and reject GTE's assertions that the model is flawed.

194.   We disagree with GTE's assertion that the use of generalized fill factors are not proper inputs for a cost model that seeks to estimate the forward-looking costs of building a network. GTE claims that the use of generalized fill factors disregards how actual distribution plant is designed and that different levels of utilization are observed in different parts of the local network.[407] However, we find that GTE's concerns are misplaced. Contrary to GTE's implication, generalized fill factors are an administrative input and are not the sole determinate of the effective fill factor. As we explained in the *Inputs Further Notice*, the effective fill factor will vary with the number of customer locations and the available discrete size of cable.[408] Thus, the effective fill factor will reflect how distribution plant is designed and different levels of utilization that are observed in different parts of the local network.

195.   Similarly, we disagree with GTE's assertion that company-specific information should be used to determine appropriate fill factor inputs.[409] We note that the final effective fill factors are the result of the input of the administrative fill factors and company-specific customer location data. We also disagree with the contention that administrative fill factors

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[405]   *Inputs Further Notice* at para. 102.

[406]   Sprint *Inputs Further Notice* comments at 29; SBC *Inputs Further Notice* comments at 9; GTE *Inputs Further Notice* comments at 54.

[407]   GTE *Inputs Further Notice* comments at 53.

[408]   *Inputs Further Notice* at para. 96 n. 135.

[409]   GTE *Inputs Further Notice* comments at 54. Ameritech contends that the nationwide fill factors proposed by the Commission are reasonable estimates to use if company-specific or state-specific fill factors are not used. Ameritech *Inputs Further Notice* comments at 20.

must be company-specific.[410] The administrative fill factors are determined per engineering standards and density zone conditions. These factors are independent of an individual company's experience and measured effective fill factors. The administrative fill factors would be the same for every efficient competitive firm.

196. We reject GTE's contention that the model should be modified to accept the number of pairs per location to determine the required amount of distribution plant rather than using fill factors.[411] GTE claims that this is necessary because using fill factor inputs produces anomalous results. GTE contends that the use of fill factors causes the number of implicit lines per location to decrease as density increases, in contrast to what occurs in reality. There are, according to GTE, always more business customers in higher density zones; therefore, the number of lines that must be provisioned per location should increase as density increases.

197. We find that there is no need to modify the model to accept pairs per location rather than fill factors, as GTE contends. The number of implicit lines per location does not decrease in the model as GTE claims. On the contrary, the number of implicit lines per location increases as a function of the number of business lines. The model will build to the level of business demand. With business demand increasing as a function of density, the model generates a higher number of lines per location as density increases. In sum, the anomaly that GTE identifies does not exist. GTE's claim reflects a misunderstanding of the model's operation.

198. Finally, we disagree with GTE's assertion that there is an error in the way the model calculates density zones that prevents correct application of zone-specific inputs.[412] As GTE explains, after the model has assigned customer locations to clusters, it constructs a "convex hull" around all locations in the cluster. The model then calculates density as the lines in the cluster divided by the area within the convex hull. GTE claims that the calculated densities will be higher than those observed in the real world because the denominator excludes all land not contained in the convex hull. While we agree with GTE's description of how the model determines cluster density, we find GTE's claim that this methodology is erroneous to be misplaced. In sum, GTE argues that the model employs a restricted definition of area which causes the model to use excessively high utilization factors.[413] In other words, the issue is whether the model should recognize all of the area around a cluster. We conclude

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[410] *See e.g.*, GTE *Inputs Further Notice* comments at 54; BellSouth *Inputs Further Notice* comments, Attachment B at B-12

[411] GTE *Inputs Further Notice* comments at 54.

[412] GTE *Inputs Further Notice* comments at 55.

[413] We note that GTE did not assert that this bias will increase structure costs.

that it should not. If the land outside the convex hull were included in the denominator, as GTE implies it should, the denominator would recognize unoccupied areas where no customers reside. As a result, the model would select density zone fill factors that are lower than needed to service the customers in that cluster. There would be a downward bias in the model fill factors. Thus, there is not an error in the way the model calculates density zones, as GTE contends. The model generates density values that correspond to the way the population is dispersed. To do otherwise would introduce a bias and distort the forward-looking cost estimates generated by the model.

199.   Distribution Fill Factors. We also affirm our tentative conclusion that the fill factors selected for use in the federal mechanism generally should reflect current demand and not reflect the industry practice of building distribution plant to meet ultimate demand. As we explained in the Inputs Further Notice, the fact that industry may build distribution plant sufficient to meet demand for ten or twenty years does not necessarily suggest that these costs should be supported today by the federal universal service support mechanism.[414]

200.   We find unpersuasive GTE's assertion that the input values for distribution fill factors should reflect ultimate demand.[415] In concluding that the fill factors should reflect current demand, we recognized that correctly forecasting ultimate demand is a speculative exercise, especially because of rapid technological advances in telecommunications. For example, we note that ultimate demand decreases substantially when computer modem users switch from dedicated lines serving analog modems to digital subscriber lines where one pair of copper wire provides the same function as a voice line and a separate dedicated line. Given this uncertainty, we find that basing the fill factors on current demand rather than ultimate demand is more reasonable because it is less likely to result in excess capacity, which would increase the model's cost estimates to levels higher than an efficient firm's costs and could potentially result in excessive universal service support payments.

201.   Significantly, we note that, contrary to GTE's inference, current demand as we define it includes an amount of excess capacity to accommodate short-term growth.[416] We find that GTE has not provided any evidence that demonstrates that the level of excess capacity to accommodate short-term growth is unreasonable. Rather, GTE claims that, if distribution is not built to reflect ultimate demand there will be delays in service and increased placement costs due to the need to reinforce distribution plant in established

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[414]   Inputs Further Notice at para. 100.

[415]   GTE Inputs Further Notice comments at 55-56.

[416]   GTE Inputs Further Notice comments at 55-56.

neighborhoods on a regular basis.[417] GTE also contends that telephone companies do not design distribution plant with the expectation that it will require reinforcement because that is rarely the least-cost method of placing plant.[418] GTE also claims that, in a competitive environment, facilities-based competitors would build plant to serve ultimate demand.[419] We find, however, that these unsupported claims do not demonstrate that reflecting ultimate demand in the fill factors more closely represents the behavior of an efficient firm and will not result in the modeling of excess capacity. Finally, we find that we did not misinterpret the meaning of building distribution plant to serve "ultimate demand," as GTE asserts.[420] Rather, we refused to engage in the highly speculative activity of defining "ultimate demand." Moreover, we believe that universal service support will be determined more accurately considering current demand, and not ultimate demand. Although firms may have installed excess capacity, it does not follow that the cost of this choice should be supported by the universal service support mechanism. As growth occurs, however, we anticipate that the requirement for new capacity will be reflected in updates to the model.[421]

202.   Concomitantly, we adopt the proposed values for distribution fill factors. As we explained in the *Inputs Further Notice*, the model designs outside plant to meet current demand in the same manner as the HAI model.[422] Accordingly, it is appropriate to choose fill factors that are set at less than 100 percent. We conclude that, based on the record before us, the proposed values reflect the appropriate fill factors needed to meet current demand.

203.   There is divergence among the commenters with regard to the adoption of the proposed values for the distribution fill factors. Sprint does not object to the use of the proposed values, stating that "they appear to reasonably represent realistic, forward-looking practices."[423] As noted above, Ameritech contends that the copper distribution and feeder fill factors are reasonable estimates to use if company-specific or state-specific fill factors are not used.[424] In contrast, SBC disagrees with the HAI proponents' claim that the level of spare

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[417] GTE *Inputs Further Notice* comments at 55.

[418] GTE *Inputs Further Notice* comments at 55.

[419] GTE *Inputs Further Notice* comments at 55.

[420] GTE *Inputs Further Notice* comments at 56.

[421] We anticipate beginning a proceeding in the near future to determine how to incorporate changed circumstances such as these into the modeling process.

[422] *Inputs Further Notice* at para. 100.

[423] Sprint *Inputs Further Notice* comments at 29.

[424] Ameritech *Inputs Further Notice* comments at 20.

capacity provided in the proposed values is sufficient to meet current demand plus some amount of growth.[425] SBC, however, offers no controverting evidence demonstrating that the proposed values are insufficient to meet current demand plus short-term growth. We find that the lone fact that SBC disagrees is insufficient to controvert our conclusion that the proposed values reflect the appropriate fill needed to meet current demand. BellSouth contends that the proposed values will significantly understate distribution cable requirements.[426] BellSouth submits instead projected fill factors for its distribution copper, feeder copper, and fiber cables determined by BellSouth network engineers. We find these estimates unsupported. Similarly, Bell Atlantic contends that the proposed fill factors for feeder and distribution are too high and recommends we adopt its proposed fill factors.[427] We find these recommended fill factors unsupported. We, therefore, select the proposed values for distribution fill factors.

204. We also disagree with AT&T and MCI's contention that the proposed values for the distribution fill factors are too low. AT&T and MCI claim that distribution fill factors of 1.2 lines per household are more than adequate in a forward-looking cost study.[428] We disagree. We find that 1.2 lines per household are inadequate because they simply reflect the existing provision of telephone service and are less than current demand as we define it herein.[429] Moreover, AT&T and MCI's claim is belied by their own assertions. AT&T and MCI contend that the "proposed conservative fill factors will ensure sufficient plant capacity to accommodate potentially unaccounted service needs in the PNR data."[430] AT&T and MCI also state that "[t]he fill levels used in HAI provides more than enough spare capacity for service work, churn, and unforeseen spikes in demand.[431] In sum, AT&T and MCI attest to the reasonableness of not only use of the HAI default values for distribution plant, but also the use of the average of the HAI and BCPM default values for copper feeder.

205. We also disagree with AT&T and MCI's claim that higher factors are appropriate because the model's sizing algorithm produces effective fill factors that are lower

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[425] SBC *Inputs Further Notice* comments at 9.

[426] BellSouth *Inputs Further Notice* comments, Attachment B at B-11.

[427] Bell Atlantic *Inputs Further Notice* comments, Attachment D at 7 (Proprietary Version); Bell Atlantic *Inputs Further Notice* reply comments, Attachment A at A-1.

[428] AT&T and MCI *Inputs Further Notice* comments at 22-23.

[429] *See* FCC, Common Carrier Bureau, Industry Analysis Division, *Trends in Telephone Service* at 20-6 (rel. Sept. 1999).

[430] AT&T and MCI *Inputs Further Notice* comments at 8.

[431] AT&T and MCI *Inputs Further Notice* reply comments at 20.

than optimal values.[432] As we explained in the *Inputs Further Notice*, because cable and fiber are available only in certain sizes, the effective fill factor may be lower than the administrative fill factor adopted as an input.[433] We find that AT&T and MCI's claim ignores this fact.

206.   Finally, we note that AT&T and MCI also claim that the factor should be higher because universal service support does not include residential second lines or multiple business lines. The Commission has never acted on the recommendation in the *First Recommended Decision* that only primary residential lines should be supported.[434] Moreover, we also note that AT&T and MCI's claim ignores the sixth criterion, which requires that:

> The Cost Study or model must estimate the cost of providing
> service for all businesses and households. . . Such inclusion of
> multi-line business services and multiple residential lines will
> permit the cost study or model to reflect the economies of scale
> associated with the provision of these services.[435]

In sum, we find AT&T and MCI's claim in this regard unpersuasive.

207.   Feeder Fill Factors. We also affirm our tentative conclusion to adopt copper feeder fill factors that are the average of the HAI and BCPM default values. The divergence among the commenters noted above with regard to the use of the average of the HAI and BCPM default values for the distribution fill factors is reflected in the comments regarding the proposed feeder fill factors. Sprint finds that use of the average of the HAI and BCPM default values for feeder fill factors is reasonable.[436] Ameritech's conditional support was noted above. In contrast, BellSouth contends that the average of the HAI and BCPM default values will significantly understate copper feeder cable requirements.[437] As noted above, BellSouth advocates the use of projected fill factors for copper feeder determined by BellSouth network engineers. Similarly, Bell Atlantic contends that the feeder fill factors are

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[432]   AT&T and MCI *Inputs Further Notice* comments at 22.

[433]   *Inputs Further Notice* at para. 96 n. 185.

[434]   *See First Recommended Decision*, 12 FCC Rcd at 91-92, 132-134, paras. 4, 89-92.

[435]   *Universal Service Order*, 12 FCC Rcd at 8915, para. 250.

[436]   Sprint *Inputs Further Notice* comments at 29.

[437]   BellSouth *Inputs Further Notice* comments, Attachment B at B-11.

too high.[438] We reject the use of these fill projections for copper feeder for the reasons enumerated above. We also reject, for the reasons enumerated above, AT&T and MCI's contention that feeder fill factors based on the average of the HAI and BCPM default values are too low.

208. Fiber Fill Factors. Finally, we affirm our tentative conclusion that the input value for fiber fill in the federal mechanism should be 100 percent. The majority of commenters addressing this specific issue agree with our tentative conclusion.[439] AT&T and MCI contend that fiber feeder fill factors of 100 percent are appropriate because the allocation of four fibers per integrated DLC site equates to an actual fill of 50 percent, since a redundant transmit and a redundant receive fiber are included in the four fibers per site.[440] AT&T and MCI explain that, because fiber capacity can easily be upgraded, 100 percent fill factors applied to four fibers per site are sufficient to meet unexpected increases in demand, to accommodate customer churn, and, to handle maintenance issues. Similarly, SBC asserts that fiber fill factors of 100 percent can be obtained because they are not currently subject to daily service order volatility and are more easily administered.[441] In contrast, BellSouth advocates that we employ projected fills estimated by BellSouth engineers.[442] As noted above, these estimates are unsupported and we reject them accordingly. In sum, we find that the record demonstrates that it is appropriate to use 100 percent as the input value for fiber fill in the federal mechanism.

6. **Structure Costs**

   a. **Background**

209. Outside plant structure refers to the set of facilities that support, house, guide, or otherwise protect distribution and feeder cable.[443] We explained that aerial structure

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[438] Bell Atlantic *Inputs Further Notice* comments, Attachment D at 7 (Proprietary Version); Bell Atlantic *Inputs Further Notice* reply comments, Attachment A at A-1.

[439] *See e.g.*, AT&T and MCI *Inputs Further Notice* comments at 22; Sprint *Inputs Further Notice* comments at 30; GTE *Inputs Further Notice* comments at 56; SBC *Inputs Further Notice* comments at 9-10.

[440] We note that GTE agrees with a fill factor of 100 percent for fiber as it relates to 100 percent redundancy only if it provides fibers for redundant optical transmit and receive and does not equate to 100 percent fiber utilization. We note that a fill factor of 100 percent for fiber does not equate to 100 percent fiber utilization.

[441] SBC *Inputs Further Notice* comments at 9-10.

[442] BellSouth *Inputs Further Notice* comments, Attachment B at B-9 - B-10.

[443] *Inputs Further Notice* at para. 104.